

University of Groningen

Memory and discounting

Bao, Te; Yu, Xiaohua

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version

Publisher's PDF, also known as Version of record

Publication date:

2015

[Link to publication in University of Groningen/UMCG research database](#)

Citation for published version (APA):

Bao, T., & Yu, X. (2015). *Memory and discounting: theory and evidence*. (SOM Research Reports; Vol. 15017-EEF). University of Groningen, SOM research school.

Copyright

Other than for strictly personal use, it is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license (like Creative Commons).

The publication may also be distributed here under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license. More information can be found on the University of Groningen website: <https://www.rug.nl/library/open-access/self-archiving-pure/taverne-amendment>.

Take-down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Downloaded from the University of Groningen/UMCG research database (Pure): <http://www.rug.nl/research/portal>. For technical reasons the number of authors shown on this cover page is limited to 10 maximum.



university of
 groningen

faculty of economics
and business

15017-EEF

Memory and Discounting: Theory and Evidence

Te Bao
Xiaohua Yu



SOM is the research institute of the Faculty of Economics & Business at the University of Groningen. SOM has six programmes:

- Economics, Econometrics and Finance
- Global Economics & Management
- Human Resource Management & Organizational Behaviour
- Innovation & Organization
- Marketing
- Operations Management & Operations Research

Research Institute SOM
Faculty of Economics & Business
University of Groningen

Visiting address:
Nettelbosje 2
9747 AE Groningen
The Netherlands

Postal address:
P.O. Box 800
9700 AV Groningen
The Netherlands

T +31 50 363 9090/3815

www.rug.nl/feb/research



Memory and Discounting: Theory and Evidence

Te Bao

Faculty of Economics and Business, Department of Economics, Econometrics

t.bao@rug.nl

Xiaohua Yu

Courant Research Centre "Poverty, Equity and Growth", Georg-August-Universität
Göttingen

Memory and Discounting: Theory and Evidence¹

Te Bao,
Assistant Professor of Economics,
Department of Economics, Econometrics and Finance,
Faculty of Economics and Business,
University of Groningen.
Netherlands
Email: T.Bao@rug.nl.

Xiaohua Yu,
Chair Professor of Agricultural Economics in Developing and Transition Countries,
Courant Research Centre “Poverty, Equity and Growth”,
Georg-August-Universität Göttingen.
Germany
Tel: 0049-551-3919574
Email: xyu@gwdg.de.

¹ We benefited from helpful comments by Soo Hong Chew, Ninghua Du and Guocheng Wang and the participants of 2015 Annual Meeting of Chinese Game Theory and Experimental Economics Association, Dalian, China.

Memory and Discounting: Theory and Evidence

Abstract:

Heterogeneous memory capacity has been neglected in economics literature, though it may have profound economic implications. Adopting the concept of “memory utility” proposed by Gilboa, Postlewaite and Samuelson (2015), we explore the relationship between memory capacity and individual discounting behavior by building a simple two-period model and comparing its predictions with experimental data. Both theoretical and experimental evidences confirm that memory capacity and discounting rates are positively correlated.

Keywords: Memory utility, intertemporal consumption, Individual Discounting Rates, time preference.

JEL Classification: C91, D90.

Introduction

Economic theory typically assumes that people discount future benefits compared to the same amount of benefit that they could enjoy immediately. Two main explanations, as discussed in the literature, for discounting behavior are impatience (i.e. a time preference) and fear of uncertainty in the future, e.g. risk of death (i.e. a risk preference). Andreoni and Sprenger (2012a, b) argue that time preference and risk preference are different and can be estimated separately, followed by the discussion by Andreoni and Sprenger (2015), Cheung (2015), Epper and Fehr-Duda (2015) and Miao and Zhong (2015).

In this paper, we argue that memory could play an important role in explaining discounting behavior. Memory plays an important role in our behavior as a key factor in shaping our decisions. Compared with psychological literature that has paid ample attention to memory, economic literature only explores this issue in a very limited way. Dating back to 1759, Adam Smith (2009, p. 152) already observed that “We can entertain ourselves with memories of past pleasures....”

which implies that past pleasant memories could yield current utility. Gilboa, Postlewaite and Samuelson (2015) recently developed a new concept known as “memory utility”, which connotes that current utility depends not only on current consumption, but also on past consumption. Our work takes this idea very seriously by searching for empirical and experimental evidences for it. Ignoring the heterogeneity in memory capacity could lead to substantial bias particularly in estimation of discounting behaviors.

Adopting the concept of “memory utility”, we attempt to explain the links between memory capacity and individual discounting behavior. If the pleasure enjoyed today generates long-lasting positive memories for the future, which is then added to future utility, an agent who maximizes his/her total utility during their lifetime should naturally allocate more consumption to earlier periods. Memory serves as a premium for consuming today rather than in the future. Therefore, our model predicts that the ability to memorize is positively correlated with discounting, which is supported by experimental data.

It is well-known that experimentally elicited discount rates are often higher than what seems reasonable for economic decision-making, and Andreoni and Sprenger (2012 b) attribute it to the present bias (Laibson, 1997, Benhabib et al. 2010, and Chark et al. 2015). However, the root of present bias is not yet well explained. The conjecture that memory capacity and discounting rates are correlated then could partly explain the present bias (Andreoni and Sprenger; 2012a, b), as the experiments are conducted for college student subjects, who are often young and have higher memory capacity due to selection.

This is not the first study looking at utility from memory and discounting. To our knowledge, utility from memory has been discussed by Loewenstein and Elster (1992), together with utility from anticipation. More recently, Gilboa, Postlewaite and Samuelson (2015) set up a complete theoretical framework for introducing memory utility to economic analysis. The purpose of studying this question is to understand a wide class of phenomena that seemingly confront standard economic theory on intertemporal consumption. For example, why do a young couple spend one quarter of their combined annual income on a wedding and honeymoon?

The answer provided by Gilboa, Postlewaite and Samuelson (2015) is that a wedding and a honeymoon are memory goods. While the consumption usually takes place when young, people derive utility from it when they recall it at later stages in their lifetime. Therefore, spending a large

amount of money on these non-durable goods may be an optimal choice. However, memory utility may make it harder for people to postpone their consumption and to act as if they have higher discount rate. Their theoretical framework is further developed by Hai, Krueger and Postlewaite (2015) to explain the welfare cost of consumption fluctuations. Our paper argues one step further: if memory makes people behave as if they are more impatient, the elicited discount rate should be positively correlated with the memory capacity. The paper adopts the memory span test from the psychological literature (e.g. Miller 1956) to measure the individual memory capacity, which is then linked to discounting rates. The positive correlation between memory and discount rate found in our paper serves as a strong evidence for the existence of memory utility suggested by Gilboa, Postlewaite and Samuelson (2015).

The rest of the paper is organized as the followings: Section 2 presents the theoretical framework, Section 3 reports the experimental evidence, and Section 4 concludes.

Theory

- **Benchmark**

We start from a basic two-period consumption model ($t = 0, 1$) with a single commodity good. Our model is a simplification (special case) of the model of a two-good economy in Gilboa, Postlewaite and Samuelson (2015). The total utility for a consumer is

$$U = u(c_0) + \frac{1}{1+r} u(c_1) \quad (1)$$

with intertemporal budget constraint:

$$w_0 = c_0 + (1+i)c_1 \quad ; \quad (2)$$

where $u(c_0)$ and $u(c_1)$ denote the utilities at period 0, and period 1, which are respectively derived from consumption c_0 and c_1 . w_0 denotes the total permanent income at period 0; and r and i are the discounting rate and market interest rate respectively.

Equation (2) is a typical overlapping generations model without involvement of memory goods.

- **Model with memory utility**

Following Gilboa, Postlewaite and Samuelson (2015), consumption at t does not only depend on the current consumption c_t , but also depends on the consumption in the past, which is defined as memory utility. Equation (1) can be rewritten as

$$U = u(c_0) + \frac{1}{1+r} u(c_1, c_0) \quad (3)$$

If we assume $u(c_1, c_0)$ is additive, and specifically,

$$u(c_1, c_0) = u(c_1) + \rho u(c_0) \quad (4)$$

where $\rho u(c_0)$ is the memory utility, the utility derived from the memory of $u(c_0)$ at period 1. Here ρ is defined as memory capacity, and $\rho > 0$. In the highly cited paper “The magical number seven, plus or minus two”, Miller (1956) finds that human have limited and heterogeneous memory capacities. One can speculate that if a consumer has a better memory, his/her memory utility is higher.

Combining equations (3) and (4) yields

$$U = \frac{1}{1+r} [u(c_0) + \frac{1}{1+r+\rho} u(c_1)] \quad (5)$$

When maximizing the utility in Equation (5) with the budget constraint of Equation (2), the observed discounting rate with memory utility for intertemporal choice becomes

$$r^* = r + \rho \quad (6)$$

Equation (6) implies that when memory utility exists, consumers appear to make decision based on the Observed Discounting Rate r^* which involves in memory effects, rather than the market discounting rate, as memory utility cannot be observed. Particularly, the observed discounting rate is positively correlated with memory capacity. Thus, we have the following proposition:

Proposition 1:

When a consumer has memory utility, his/her (observed) discount rate is higher when his/her memory capacity is higher.

The current experimental literature finds that discounting rates are often unusually higher when the experimental subjects are college students. Proposition 1 could partly explain this phenomenon because students often have higher memory capacity than the general public, because they are young, well trained, and highly selected. One can speculate that better memory could lead to better school performance.

The current literature has studied in-depth both memory and discounting rates, but the linkage between them is still missing. The paper will later empirically study the linkage between the two variables via a simple experiment, and then verifies the proposition 1.

- **Risk Aversion**

The current literature also suggests that risk aversion is linked to discounting rates, as people fear of uncertainty in the future. However, Following Andreoni and Sprenger (2012b), we could further extend our theory by specifying a utility function with inclusion of risk aversions. We assume the CRRA (Constant relative risk aversion) utility function $u(c) = \frac{c^\alpha}{\alpha}$, in which the relative risk aversion is measured as $\frac{1}{1-\alpha}$. When $\alpha < 1$, the consumer is risk-aversion; When $\alpha = 1$ he/she is risk-neutral; and When $\alpha > 1$ he/she is risk-loving.

Maximizing the utility in Equation (1) in the case of no memory utility yields

$$c_0^* = \frac{1}{1 + (1+i)^{\frac{\alpha}{\alpha-1}} (1+r)^{\frac{1}{\alpha-1}}} w_0 \quad . \quad (7)$$

Analogously, maximizing the utility in Equation (5) in the case of memory utility under the budget constraint (2), we have

$$c_0^* = \frac{1}{1 + (1+i)^{\frac{\alpha}{\alpha-1}}(1+r+\rho)^{\frac{1}{\alpha-1}}} w_0 \quad (8)$$

Comparing Equation (7) with (8), we obtain $c_0^* > c_0$ for $\rho > 0$ and $\alpha < 1$ (risk-aversion consumer). That is

Lemma 1:

When there is memory utility, a risk-aversion consumer tends to allocate more budgets to the current period, compared with the case without memory utility.

Intuitively, consumers with memory utility could obtain more utility when more budgets are allocated to the period 0, which could then compensate the utility loss in period 1 through memory utility.

In addition, when $\alpha < 1$, Equation (8) also shows that

$$\frac{\partial c_0^*}{\partial \rho} > 0.$$

This yields

Lemma 2:

A risk-aversion consumer with higher memory capacity allocates more budgets to the current period, and save less for the future when memory utility exists.

Also, the fact that more budgets are allocated to current period implies that the consumer has a higher discounting rate. Thus, Lemma 2 is consistent with Proposition 1. In practice, people tend to spend a lot of money on weddings and for tourism, particularly young people, because they could yield ample memory utility, which could contribute to later utility.

From the empirical perspective, Equation (8) demonstrates that risk aversion and discounting rate could be disentangled, and similar results are showed in studies of Andreoni and Sprenger (2012b).

However, both Equation (5) and Equation (8) shows that the true discounting behavior r cannot be disentangled from memory capacity ρ , as we only observed the discounting rate $r^* = r + \rho$. As proposed by Proposition 1, the observed discounting rate is positively correlated with memory capacity. This will be tested in the following experiment, where we develop a method to elicit the heterogeneity of memory capacity.

Experiment

- Measuring memory capacity

Psychological literature has distinguished three types of memory: sensory, short-term and long-term (Kassin 2006, pp.235) according to human information processing mechanism. Sensory memory records information from the senses for a very short time, for example, three seconds. However, sensations that do not draw attention tend to be forgotten, but those we notice are transferred to short-term memory. The short-term memory fades quickly, and only some information turns into long-term memory which can be stored for many years. The information process and the three types of memory are demonstrated in Figure 1.

Short-term memory is the critical chain linking sensory memory and long-term memory, and has been well studied in the literature. It is very difficult to measure sensory memory and long-term memory objectively. As the information processing time is very short for sensory memory, and very long for long-term memory, they cannot be measured accurately. In contrast, psychological literature pays attention to the study on short-term memory capacity. Figure 1 demonstrates that the short-term memory should be correlated with long-term memory capacity.

[Insert Figure 1 here]

Limited by attention resources, short-term memory can hold only a small number of items. In the famous memory span task test, Miller (1956) described the human short-term capacity as “the magical number seven, plus or minus two”. In other words, the average length of items that can be recorded in short-term memory is seven, with plus or minus two. His experiment has been

replicated on many later occasions, and many studies have found that our short-term memory capacity is actually more limited than what Miller suggested (Cowan 2000). Such an experimental design is widely regarded as a good tool for measuring memory capacity.

Following Miller (1956), Baddeley (1992) and Cowan (2000), a *Memory Span Task* experiment is conducted in this study to measure memory capacity. Our subjects are college students, and are believed to have above average memory capacities. Specifically, we use a computer to generate 13 random number sequences, increasing successively from 2 digits to 14 digits (the number sequences are reported in Appendix 2). Each of the 13 number sequences are put separately on 13 PowerPoint slides, in an order of increasing number of digits, and are shown to the experiment subjects one by one. Each slide is shown for two seconds. Between every second slide a 10-second pause is provided for the subjects to write down the number on the previous slide on a notebook distributed by the experiment conductor. Memory capacity is measured by the number of digits in the longest number sequence a subject is able to write down, before the first mistake is made.

- Measuring discounting rates

Though individual discounting rates cannot usually be directly observed, Collier and Williams (1999) first developed an experiment to elicit this by comparing a list of different payment scenarios with different effective interest rates. Since then, the so-called multiple price list (MPL) is widely adopted in many experimental studies in eliciting time preference. Though some literature argues that time preference is often confounded with risk aversion (Holt and Laury 2002), the paper by Andreoni and Sprenger (2012a) and its comments suggest time preference can be elicited without risk preference. In the case of CRRA, Equation (8) in this paper demonstrates the very finding that risk aversion can be separated from time preference. Therefore, we did not combine the time preference elicitation task with the risk elicitation task.

The MPL method of Collier and Williams (1999) is adopted in this study for measuring individual discounting rates. Given a table, subjects are asked to choose between two options, A and B. Option A offers 3000 yuan at present, and B offers 3000 yuan plus an interest payments (the list of choices is reported in Appendix 1). The subjects make their choices from 10 rows in which A remains the same and the interest payment for B is increasing. The switching point from A to B is used to calculate the subjects' discount rate. Then we could calculate the yearly interest rates (YIR)

and effective yearly interest rates (EYIR) respectively. The questions about time preference are hypothetical. Subjects do not receive the money they choose in their answer form. Coller and Williams (1999) conducted 6 sessions in their experiment, including both real and hypothetical payments. They find that the discounting rates for hypothetical payments are lower, but their results might be not robust because the sample size is relative small.

- Experiment implementation

Our data was collected in March-May, 2015 at Nanjing Agricultural University, Jilin Agriculture University, and Jilin University of Finance and Economics in China. We have 587 participants. All subjects are university students, and are recruited by our research partners in these three universities. Such a large sample could yield a robust result from a statistical perspective. The experiments are conducted in the following steps:

Step 1: Collect basic demographic information, such as age and gender of the subjects.

Step 2: Ask the subjects to elicit individual discounting rates using the table in Appendix 1.

Step 3: Show the 13 slides with the number sequences of the memory span task to elicit heterogeneities of individual memory capacity.

This experiment is also combined with a dictator game, but that was run after the experiment. The total duration of the whole session is typically around 40 minutes, and the subjects receive their payoffs based on their decision in the dictator game.

After deleting abnormal samples, for instance inconsistent answers in eliciting the individual discounting rates, we obtain 552 effective observations.

Experimental Results

Table 1 reports the descriptive statistics of the experimental results. The average age of the subjects is 20.71 years, with a standard deviation of 2.17 years. The percentage of male participants is 26.24%. The average number of correct numbers in the memorizing task is 9.31 out of 14, with a standard deviation of 1.78. It is higher than the finding of Miller (1956). However, it is

comprehensible as the participants are college students who should have better memory capacity after training and selection of the college-entrance exams in China. Without considering censoring effects, the YIR (yearly interest rate) is 25.06%, with a standard deviation of 12.66%. Corresponding, the EYIR (effective yearly interest rate) is 28.20%, with a standard deviation of 15.30%. The discounting rates seems slightly higher than the results in Coller and Williams (1999), who report that YIR and EYIR fall in the intervals 17.5-20% and 19.1-22.1% respectively. But they are comparable because the samples in our study are young college students.

[Insert Table 1 here]

To obtain a quick overview of the relation between discount and memory, we plot the average discount rate at each memory level. Figure 2 shows this plot. There is strong indication of a positive correlation between the two variables. We also show the average discount rate by age and gender. There is an indication of a negative correlation between age and discount rate, and the average discount rate is higher for men than for women.

Next, we regress the discount rate on memorizing ability, age and gender.

$$Discount_Rate = \beta_0 + \beta_1 memory + \beta_2 male + \beta_3 age + \epsilon \quad (9)$$

In the econometric model, *Discount_Rate* can be proxied by YIR and EYIR.

Coller and Williams (1999) proposes that there is a censoring mechanism in the MPL method. For instance, there are 19 subjects selected all “A” choices, which means that their discounting rates are smaller than 5%; while there are 38 subjects selected all “B” choices, which implies that their discounting rates are greater than 50%. We adopt the interval regression method proposed by Amemiya (1973) to estimate Equation (9). Both the results for YIR and EYIR are reported in Table 2.

[Insert Figure 2 and Table 2 here]

The results for the YIR and EYIR are similar, except that the coefficients for EYIR are slightly larger. It makes sense that the EYIR is higher than YIR. The likelihood ratio tests for model specification are highly significant (1%). It indicates that the interval regression models fit the data very well.

The coefficients for Memory are 0.76 and 0.92 respectively for YIR and EYIR models, and they are statistically significant at 5%. It proves our hypothesis that memory capacity is positively correlated with the discounting rates. Controlling other variables, an increase in one digit in memory span test, the discount rate will increase by 0.76%.

The coefficients for the Male dummy variable are 5.28 and 6.43 respectively for YIR and EYIR, and both statistically significant at 1%. It implies that the discounting rate for the male is 5.3% higher than female.

Finally, the coefficients for age are -1.07 and -1.28 respectively for YIR and EYIR, and both statistically significantly at 1% as well. It implies that the young people have higher discounting rate, even though the memory capacity is controlled. Recalling the concept of “memory utility”, young people could have long time to enjoy the memory utility if more expenses are allocated to young age.

Conclusion

Adopting the concept of “memory utility” proposed by Gilboa, Postlewaite and Samuelson (2015), that current utility depends not only on current consumption but also on past consumption, we explore the relationship between memory and discounting behavior by building a simple two-period model and by comparing its predictions with experimental data. The model predicts that in most cases, the strength of memory capacity should be positively correlated with discount rate, which is well supported by the experimental data. Our work, as an extension of Gilboa, Postlewaite and Samuelson (2015), somehow confirms the validity of the new concept “memory utility” at the same time.

The current literature for experimental economics only controls observed heterogeneities, such as gender and age, but some internal and unobserved differences, such as memory capacity, have not been well studied. They doubtlessly could regulate human decision-making. For instance, neglect of the memory capacity heterogeneities could bias the experimental results, or could make the results difficult to explain.

The literature often attributes the usually high discounting rates in experimental studies to unexplainable present bias. Our finding that memory capacity and discounting rates are positively correlated then could partly explain the present bias, as the experimental subjects often are college student subjects, who usually have higher memory capacity due to young age and high selection.

For future extension of our research, it may be useful to compare memory utility for positive versus negative experiences. Chew et al. (2014) find that people have a strong tendency to forget negative past events and exhibit false memory in favor of positive events. If memory capacity is influenced by the nature of the event, it may also be translated to different observed discount rate.

References

- Amemiya, T. (1973). Regression analysis when the dependent variable is truncated normal. *Econometrica* 41:997-1016.
- Andreoni, J., and Sprenger, C. (2012a). Risk preferences are not time preferences. *American Economic Review*, 102(7), 3357-3376.
- Andreoni, J., and Sprenger, C. (2012b). Estimating Time Preferences from Convex Budgets. *American Economic Review*, 3333-3356.
- Andreoni, J., and Sprenger, C. (2015). Risk preferences are not time preferences: reply. *American Economic Review*, 105(7), 2287-93.
- Baddeley, A. (1992). Working memory. *Science*, 255(5044), 556-559.
- Benhabib, J., Bisin, A., and Schotter, A. (2010). Present-bias, quasi-hyperbolic discounting, and fixed costs. *Games and Economic Behavior*, 69(2), 205-223.
- Chark, R., Chew, S. H., and Zhong, S. (2014). Extended present bias: a direct experimental test. *Theory and Decision*, 1-15.
- Cheung, S. L. (2015). Risk Preferences Are Not Time Preferences: On the Elicitation of Time Preference under Conditions of Risk: Comment. *American Economic Review*, 105(7), 2242-60.
- Chew, S. H., Huang, W., and Zhao, X. (2014). Selective Memory and Motivated Delusion: Theory and Experiment. Available at SSRN 2127795.
- Coller, M., and Williams, M. B. (1999). Eliciting individual discount rates. *Experimental Economics*, 2(2), 107-127.
- Cowan N. (2000) The magical number 4 in short-term memory: a reconsideration of mental storage capacity. *Behavioral and brain Sciences*, Vol. 24:87-185.
- Ebbinghaus, H. (1913). *Memory: A contribution to experimental psychology* (No. 3). University Microfilms.
- Epper, T., and Fehr-Duda, H. (2015). Comment on “Risk Preferences Are Not Time Preferences”: Balancing on a Budget Line, *American Economic Review*, 105(7), 2261-2271.

Engle, R. W., Tuholski, S. W., Laughlin, J. E., and Conway, A. R. (1999). Working memory, short-term memory, and general fluid intelligence: a latent-variable approach. *Journal of experimental psychology: General*, 128(3), 309.

Ericsson, K. A., and Kintsch, W. (1995). Long-term working memory. *Psychological review*, 102(2), 211.

Gilboa, I., Postlewaite, A., and Samuelson L. (2015). Memory Utility, PIER Working Paper 15-005 , Penn Institute for Economic Research , Department of Economics , University of Pennsylvania 3718 Locust Walk Philadelphia, PA 19104-6297. Available at :

http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2554491

Hai, R., Krueger, D., and Postlewaite, A. (2015). On the Welfare Cost of Consumption Fluctuations in the Presence of Memorable Goods, PIER Working Paper No. 15-004 and Becker Friedman Institute for Research in Economics Working Paper No. 2553231.

Holt, C. A., and Laury, S. K. (2002). Risk aversion and incentive effects. *American economic review*, 92(5), 1644-1655.

Kassin S. (2006) *Psychology in Modules*, Pearson Education In.C. Upper Saddle River, New Jersey , 07458, USA .

Laibson, D. (1997). Golden eggs and hyperbolic discounting. *The Quarterly Journal of Economics*, 443-477.

Loewenstein, G., and Elster, J. (1992). Utility from memory and anticipation. in *Choice over time* (edited by Loewenstein, G., and Elster, J.), 213-234, Russell Sage Foundation, New York.

Miao, B., and Zhong, S. (2015). Risk Preferences Are Not Time Preferences: Separating Risk and Time Preference: Comment. *American Economic Review*, 105(7), 2272-86.

Miller, G. (1956). The magic number seven plus or minus two: Some limits on our capacity for processing information. *Psychological Review*, Vol. 63:81-97.

Smith A. (2009). *The Theory of Moral Sentiments*. Penguin Books, New York, 2009 (originally 1759).

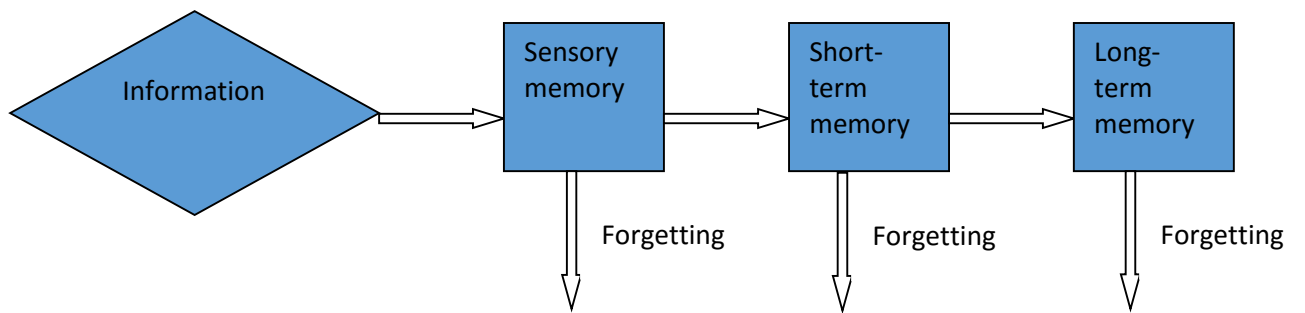


Figure 1: Information Process and Memory

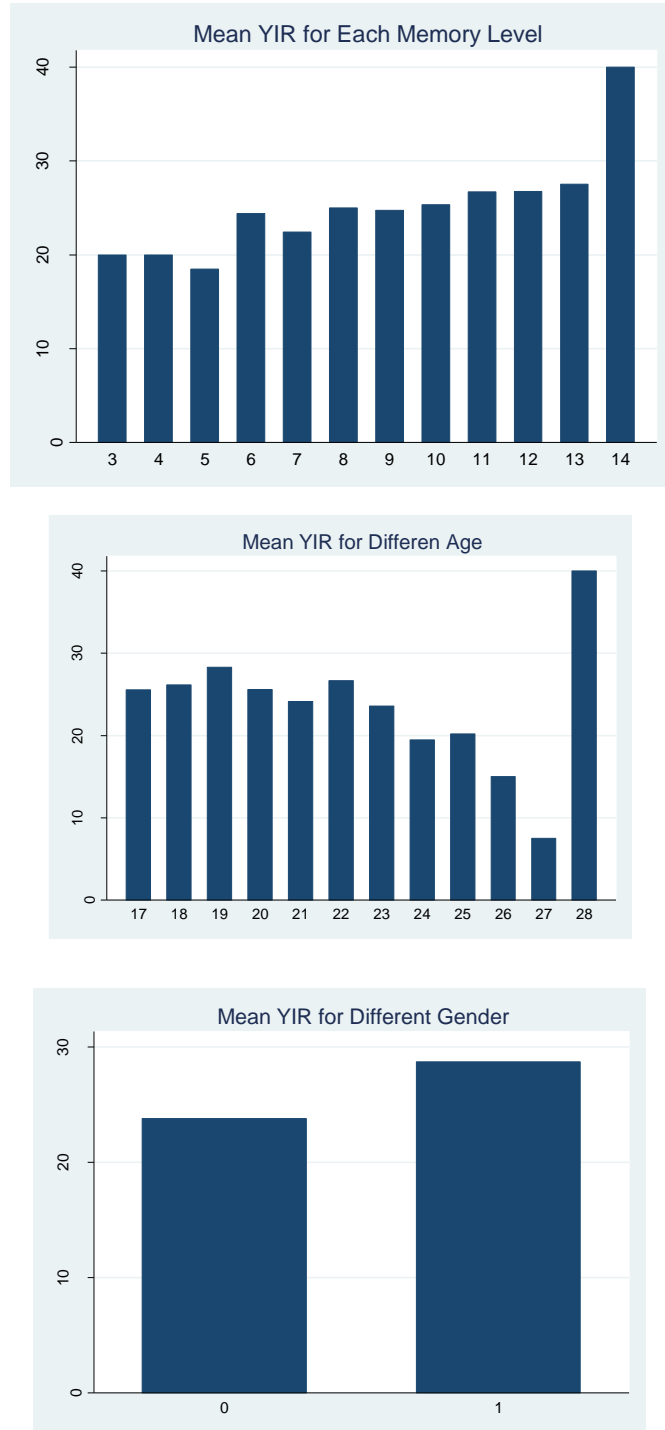


Figure 2: The average discount rate for each memory level, age and gender.

Table 1: Descriptive statistics

Variable	Definition	Mean	Std. Dev.	Min	Max
Age	Age	20.71	2.17	17	28
Male	Male=1, Female=0	0.26	0.44	0	1
Memory	No. of Maximum Digits of Memorized Number	9.32	1.74	3	14
yir	Yearly Interest Rate (%)	25.06	12.66	0	50
eyir	Effective Yearly Interest Rate (%)	28.20	15.30	0	60.18

Table 2: Regression results for the experimental results

	YIR		EYIR	
	Coeff.	t-ratios	Coeff.	t-ratios
Memory	0.76	2.44*	0.92	2.41*
Male	5.28	4.27**	6.43	4.24**
Age	-1.07	-4.29**	-1.28	-4.17**
Intercept	41.56	6.78**	47.65	6.34**
LR test for Model Specification	chi2(3) = 41.61**		chi2(3) = 40.32**	

Notes: * and ** denotes significant levels at 5% and 1% respectively.

Appendix

Appendix 1:

Task to elicit time preference.

Suppose you are going to receive an amount of money around 3000 yuan. There are two options for you to receive it: Option A allows you to receive 3000 yuan in one month, and Option B allows you to receive 3000 yuan plus some interest payment in seven months. Please make a choice between A and B in the 10 pairs of choices below:

	Option A	Option B	Yearly Interest Rate	Effective Yearly Interest Rate	Your Choice	
	In 1 month Amount	In 7 months Amount	(%)	(%)	(Circle A or B)	
1	3000	3075	5	5.09	A	B
2	3000	3152	10	10.38	A	B
3	3000	3229	15	15.87	A	B
4	3000	3308	20	21.55	A	B
5	3000	3387	25	27.44	A	B
6	3000	3467	30	33.55	A	B
7	3000	3548	35	39.87	A	B
8	3000	3630	40	46.41	A	B
9	3000	3713	45	53.18	A	B
10	3000	3797	50	60.18	A	B

Appendix 2:

Instructions for memory measurement task

Now you are going to watch 13 slides in a sequence. On each slide there is a number. Please write down the numbers on the slides in the right sequence.

Numbers on the slides:

69, 929, 1021, 34634, 943453, 7374885, 69358267, 699875725, 6655803001, 26656897198,
661518840995, 1285246589042, 91431501977497.



List of research reports

12001-HRM&OB: Veltrop, D.B., C.L.M. Hermes, T.J.B.M. Postma and J. de Haan, A Tale of Two Factions: Exploring the Relationship between Factional Faultlines and Conflict Management in Pension Fund Boards

12002-EEF: Angelini, V. and J.O. Mierau, Social and Economic Aspects of Childhood Health: Evidence from Western-Europe

12003-Other: Valkenhoef, G.H.M. van, T. Tervonen, E.O. de Brock and H. Hillege, Clinical trials information in drug development and regulation: existing systems and standards

12004-EEF: Toolsema, L.A. and M.A. Allers, Welfare financing: Grant allocation and efficiency

12005-EEF: Boonman, T.M., J.P.A.M. Jacobs and G.H. Kuper, The Global Financial Crisis and currency crises in Latin America

12006-EEF: Kuper, G.H. and E. Sterken, Participation and Performance at the London 2012 Olympics

12007-Other: Zhao, J., G.H.M. van Valkenhoef, E.O. de Brock and H. Hillege, ADDIS: an automated way to do network meta-analysis

12008-GEM: Hoorn, A.A.J. van, Individualism and the cultural roots of management practices

12009-EEF: Dungey, M., J.P.A.M. Jacobs, J. Tian and S. van Norden, On trend-cycle decomposition and data revision

12010-EEF: Jong-A-Pin, R., J-E. Sturm and J. de Haan, Using real-time data to test for political budget cycles

12011-EEF: Samarina, A., Monetary targeting and financial system characteristics: An empirical analysis

12012-EEF: Alessie, R., V. Angelini and P. van Santen, Pension wealth and household savings in Europe: Evidence from SHARELIFE

13001-EEF: Kuper, G.H. and M. Mulder, Cross-border infrastructure constraints, regulatory measures and economic integration of the Dutch – German gas market

13002-EEF: Klein Goldewijk, G.M. and J.P.A.M. Jacobs, The relation between stature and long bone length in the Roman Empire

13003-EEF: Mulder, M. and L. Schoonbeek, Decomposing changes in competition in the Dutch electricity market through the Residual Supply Index

13004-EEF: Kuper, G.H. and M. Mulder, Cross-border constraints, institutional changes and integration of the Dutch – German gas market

13005-EEF: Wiese, R., Do political or economic factors drive healthcare financing privatisations? Empirical evidence from OECD countries

13006-EEF: Elhorst, J.P., P. Heijnen, A. Samarina and J.P.A.M. Jacobs, State transfers at different moments in time: A spatial probit approach

13007-EEF: Mierau, J.O., The activity and lethality of militant groups: Ideology, capacity, and environment

13008-EEF: Dijkstra, P.T., M.A. Haan and M. Mulder, The effect of industry structure and yardstick design on strategic behavior with yardstick competition: an experimental study

13009-GEM: Hoorn, A.A.J. van, Values of financial services professionals and the global financial crisis as a crisis of ethics

13010-EEF: Boonman, T.M., Sovereign defaults, business cycles and economic growth in Latin America, 1870-2012

13011-EEF: He, X., J.P.A.M Jacobs, G.H. Kuper and J.E. Ligthart, On the impact of the global financial crisis on the euro area

13012-GEM: Hoorn, A.A.J. van, Generational shifts in managerial values and the coming of a global business culture

13013-EEF: Samarina, A. and J.E. Sturm, Factors leading to inflation targeting – The impact of adoption

13014-EEF: Allers, M.A. and E. Merkus, Soft budget constraint but no moral hazard? The Dutch local government bailout puzzle

13015-GEM: Hoorn, A.A.J. van, Trust and management: Explaining cross-national differences in work autonomy

13016-EEF: Boonman, T.M., J.P.A.M. Jacobs and G.H. Kuper, Sovereign debt crises in Latin America: A market pressure approach

13017-GEM: Oosterhaven, J., M.C. Bouwmeester and M. Nozaki, The impact of production and infrastructure shocks: A non-linear input-output programming approach, tested on an hypothetical economy

13018-EEF: Cavapozzi, D., W. Han and R. Miniaci, Alternative weighting structures for multidimensional poverty assessment

14001-OPERA: Germs, R. and N.D. van Foreest, Optimal control of production-inventory systems with constant and compound poisson demand

14002-EEF: Bao, T. and J. Duffy, Adaptive vs. educative learning: Theory and evidence

14003-OPERA: Syntetos, A.A. and R.H. Teunter, On the calculation of safety stocks

14004-EEF: Bouwmeester, M.C., J. Oosterhaven and J.M. Rueda-Cantuche, Measuring the EU value added embodied in EU foreign exports by consolidating 27 national supply and use tables for 2000-2007

14005-OPERA: Prak, D.R.J., R.H. Teunter and J. Riezebos, Periodic review and continuous ordering

14006-EEF: Reijnders, L.S.M., The college gender gap reversal: Insights from a life-cycle perspective

14007-EEF: Reijnders, L.S.M., Child care subsidies with endogenous education and fertility

14008-EEF: Otter, P.W., J.P.A.M. Jacobs and A.H.J. den Reijer, A criterion for the number of factors in a data-rich environment

14009-EEF: Mierau, J.O. and E. Suari Andreu, Fiscal rules and government size in the European Union

14010-EEF: Dijkstra, P.T., M.A. Haan and M. Mulder, Industry structure and collusion with uniform yardstick competition: theory and experiments

14011-EEF: Huizingh, E. and M. Mulder, Effectiveness of regulatory interventions on firm behavior: a randomized field experiment with e-commerce firms

14012-GEM: Bressand, A., Proving the old spell wrong: New African hydrocarbon producers and the 'resource curse'

14013-EEF: Dijkstra P.T., Price leadership and unequal market sharing: Collusion in experimental markets

14014-EEF: Angelini, V., M. Bertoni, and L. Corazzini, Unpacking the determinants of life satisfaction: A survey experiment

14015-EEF: Heijdra, B.J., J.O. Mierau, and T. Trimborn, Stimulating annuity markets

14016-GEM: Bezemer, D., M. Grydaki, and L. Zhang, Is financial development bad for growth?

14017-EEF: De Cao, E. and C. Lutz, Sensitive survey questions: measuring attitudes regarding female circumcision through a list experiment

14018-EEF: De Cao, E., The height production function from birth to maturity

14019-EEF: Allers, M.A. and J.B. Geertsema, The effects of local government amalgamation on public spending and service levels. Evidence from 15 years of municipal boundary reform

14020-EEF: Kuper, G.H. and J.H. Veurink, Central bank independence and political pressure in the Greenspan era

14021-GEM: Samarina, A. and D. Bezemer, Do Capital Flows Change Domestic Credit Allocation?

14022-EEF: Soetevent, A.R. and L. Zhou, Loss Modification Incentives for Insurers Under Expected Utility and Loss Aversion

14023-EEF: Allers, M.A. and W. Vermeulen, Fiscal Equalization, Capitalization and the Flypaper Effect.

14024-GEM: Hoorn, A.A.J. van, Trust, Workplace Organization, and Comparative Economic Development.

14025-GEM: Bezemer, D., and L. Zhang, From Boom to Bust in de Credit Cycle: The Role of Mortgage Credit.

14026-GEM: Zhang, L., and D. Bezemer, How the Credit Cycle Affects Growth: The Role of Bank Balance Sheets.

14027-EEF: Bružikas, T., and A.R. Soetevent, Detailed Data and Changes in Market Structure: The Move to Unmanned Gasoline Service Stations.

14028-EEF: Bouwmeester, M.C., and B. Scholtens, Cross-border Spillovers from European Gas Infrastructure Investments.

14029-EEF: Lestano, and G.H. Kuper, Correlation Dynamics in East Asian Financial Markets.

14030-GEM: Bezemer, D.J., and M. Grydaki, Nonfinancial Sectors Debt and the U.S. Great Moderation.

14031-EEF: Hermes, N., and R. Lensink, Financial Liberalization and Capital Flight: Evidence from the African Continent.

14032-OPERA: Blok, C. de, A. Seepma, I. Roukema, D.P. van Donk, B. Keulen, and R. Otte, Digitalisering in Strafrechtketens: Ervaringen in Denemarken, Engeland, Oostenrijk en Estland vanuit een Supply Chain Perspectief.

14033-OPERA: Olde Keizer, M.C.A., and R.H. Teunter, Opportunistic condition-based maintenance and aperiodic inspections for a two-unit series system.

14034-EEF: Kuper, G.H., G. Sierksma, and F.C.R. Spieksma, Using Tennis Rankings to Predict Performance in Upcoming Tournaments

15001-EEF: Bao, T., X. Tian, X. Yu, Dictator Game with Indivisibility of Money

15002-GEM: Chen, Q., E. Dietzenbacher, and B. Los, The Effects of Ageing and Urbanization on China's Future Population and Labor Force

15003-EEF: Allers, M., B. van Ommeren, and B. Geertsema, Does intermunicipal cooperation create inefficiency? A comparison of interest rates paid by intermunicipal organizations, amalgamated municipalities and not recently amalgamated municipalities

15004-EEF: Dijkstra, P.T., M.A. Haan, and M. Mulder, Design of Yardstick Competition and Consumer Prices: Experimental Evidence

15005-EEF: Dijkstra, P.T., Price Leadership and Unequal Market Sharing: Collusion in Experimental Markets



15006-EEF: Anufriev, M., T. Bao, A. Sutin, and J. Tuinstra, Fee Structure, Return Chasing and Mutual Fund Choice: An Experiment

15007-EEF: Lamers, M., Depositor Discipline and Bank Failures in Local Markets During the Financial Crisis

15008-EEF: Oosterhaven, J., On de Doubtful Usability of the Inoperability IO Model

15009-GEM: Zhang, L. and D. Bezemer, A Global House of Debt Effect? Mortgages and Post-Crisis Recessions in Fifty Economies

15010-I&O: Hooghiemstra, R., N. Hermes, L. Oxelheim, and T. Randøy, The Impact of Board Internationalization on Earnings Management

15011-EEF: Haan, M.A., and W.H. Siekman, Winning Back the Unfaithful while Exploiting the Loyal: Retention Offers and Heterogeneous Switching Costs

15012-EEF: Haan, M.A., J.L. Moraga-González, and V. Petrikaite, Price and Match-Value Advertising with Directed Consumer Search

15013-EEF: Wiese, R., and S. Eriksen, Do Healthcare Financing Privatisations Curb Total Healthcare Expenditures? Evidence from OECD Countries

15014-EEF: Siekman, W.H., Directed Consumer Search

15015-GEM: Hoorn, A.A.J. van, Organizational Culture in the Financial Sector: Evidence from a Cross-Industry Analysis of Employee Personal Values and Career Success

15016-EEF: Te Bao, and C. Hommes, When Speculators Meet Constructors: Positive and Negative Feedback in Experimental Housing Markets

15017-EEF: Te Bao, and Xiaohua Yu, Memory and Discounting: Theory and Evidence



[**www.rug.nl/feb**](http://www.rug.nl/feb)